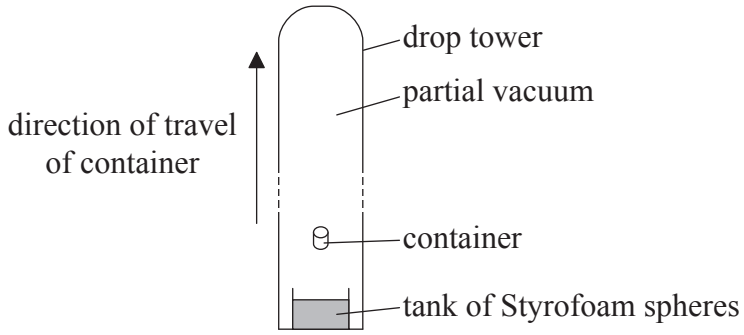
*Answer **all** questions. Write your answers in the boxes provided.*

1. In the drop tower shown, containers with experiments inside of them are fired upwards inside a vertical tower.



The container moves under the influence of gravity and eventually falls back to the bottom of the tower. Most of the air is removed from the tower so that air resistance is negligible. While in flight, the container and its contents are in free-fall.

(a) The container is fired vertically upwards with initial speed $48\,m\,s^{-1}$. Determine the time that the container is in flight. *[2]*

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(This question continues on the following page)

(Question 1 continued)

(b) At the end of the flight, the container of total mass 480 kg falls into a tank of expanded Styrofoam (polystyrene) spheres to slow it. The container stops after moving a distance of 8.0 m in the Styrofoam. Calculate the average force that acts on the container due to the spheres. *[3]*

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(c) Outline why the experiments inside the container could be considered to be in "weightless" conditions. *[2]*

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(This question continues on the following page)

(Question 1 continued)

(d) The tower is 120 m high with an internal diameter of 3.5 m. When most of the air has been removed, the pressure in the tower is 0.96 Pa.

(i) Determine the number of molecules of air in the tower when the temperature of the air is 300 K. *[3]*

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(ii) Outline whether the behaviour of the remaining air in the tower approximates to that of an ideal gas. *[2]*

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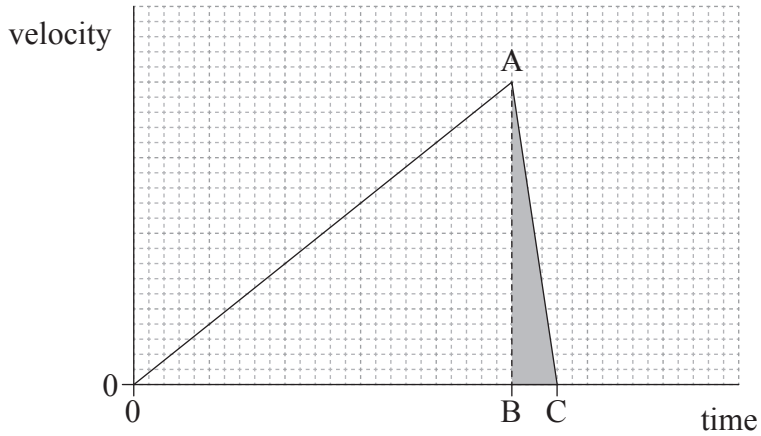
(Question 1 continued)

(e) The container can also be released from rest at the top of the tower. The graph shows how the container velocity varies with time from release with the tower in a partial vacuum.



(i) State the quantity that is represented by the shaded area ABC. *[1]*

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(ii) Air is introduced into the tower. The container is released from the top of the tower when the air in the tower is at atmospheric pressure. Using the axes in (e), sketch a graph to show how the container velocity varies with time from release when the air is at atmospheric pressure. *[3]*

2. (a) State Ohm's law. *[1]*

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(b) (i) A copper wire has a length of 0.20 km and a diameter of 3.0 mm. The resistivity of copper is $1.7 \times 10^{-8}\,\Omega\,\text{m}$. Determine the resistance of the wire. *[3]*

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(ii) A potential difference of 6.0 V is maintained across the ends of the wire. Calculate the power dissipated in the wire. *[1]*

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(iii) Explain how the flow of electrons in the wire leads to an increase in the temperature of the wire. *[3]*

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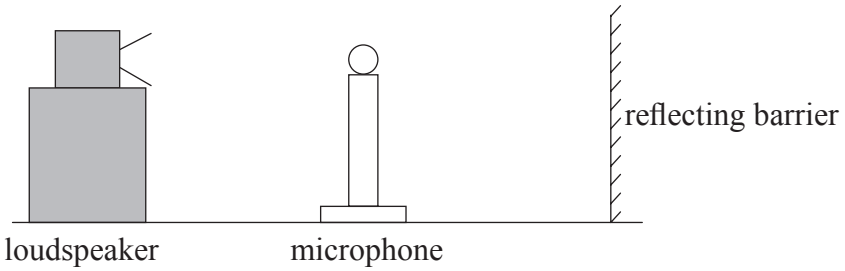
3. A loudspeaker emits sound waves of a single frequency towards a reflecting barrier.



A microphone is moved along a straight line between the loudspeaker and the barrier. A sequence of equally spaced maxima and minima of sound wave intensity is detected.

(a) Explain how the maxima and minima are formed. *[4]*

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(Question 3 continued)

(b) The microphone is moved through 1.0 m from one point of minimum intensity to another point of minimum intensity. It passes through seven points of maximum intensity as it moves. The speed of sound is 340 m s^{-1}.

(i) Calculate the wavelength of the sound waves. *[2]*

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(ii) Outline how you could use this arrangement to determine the speed of sound in air. *[3]*

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4. (a) A power station burns natural gas at a rate of $35\,kg\,s^{-1}$. The power output of the station is 750 MW and the efficiency of the station is 38 %.

(i) Calculate the energy provided by the natural gas each second. *[1]*

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(ii) Calculate the specific energy of the natural gas. State appropriate units for your answer. *[3]*

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(b) Outline why much of the world's energy is provided from fossil fuels. *[2]*

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(Question 4 continued)

(c) There is a suggestion that the temperature of the Earth may increase if the use of fossil fuels is not reduced over the coming years.

(i) Explain, with reference to the enhanced greenhouse effect, why this temperature increase may occur. *[3]*

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(ii) Outline how scientists continue to attempt to resolve the climate change debate. *[1]*

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(Question 4 continued)

(d) Nuclear power stations are one way in which energy can be generated without the use of fossil fuels. One example of a nuclear fission reaction is as shown.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{148}_{57}\mathrm{La} + {}^{85}_{35}\mathrm{Br} + x\,{}^{1}_{0}\mathrm{n}$$

(i) Identify the value of x. *[1]*

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(ii) The following data are available.

Mass of U-235 = 235.044 u
Mass of n = 1.009 u
Mass of La-148 = 148.932 u
Mass of Br-85 = 84.910 u

Determine, in MeV, the energy released when one uranium nucleus undergoes nuclear fission in the reaction in (d). *[3]*

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(Question 4 continued)

(iii) Outline, with reference to the speed of the neutrons, the role of the moderator in a nuclear reactor. *[3]*

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